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ABSTRACT

An examination of geographic theories of social change clarifies how and why Torsten Haagerstrand's ideas have revolutionized geographic thinking, particularly regarding educational change and development, and provides the background for analyzing his models in detail. Haagerstrand developed the first formal geographic model of diffusion processes, linking together certain macroconcepts which summarize the recurring characteristics of these processes--the growth curve and spatial expression of growth. The central ideas in geographic diffusion theory today are in large measure macroscopic in scale (excepting those patterned after Haagerstrand), relating to centers of innovation and spread, channels of spread, boundary effects, and receptivity factors. Haagerstrand developed three models, each a successively better means of simulating an actual diffusion process. Haagerstrand's formulations transformed geographical thinking, forcing geographers to focus on the processes producing spatial patterns in a behavioral framework, although the natural inclination of many geographers was to use his framework as a guideline for macroscale inquiries. Judith Meyer observed the parallels between education and diffusion, learning and adoption, and formulated a study of the diffusion of an educational innovation in the Haagerstrand framework. Haagerstrand's models and Meyer's work reveal several important aspects of the role of communication in social change for those interested in educational networking. (CWM)

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GEOGRAPHIC THEORIES OF EDUCATIONAL DEVELOPMENT: INNOVATION DIFFUSION WITHIN INFORMAL INTERPERSONAL NETWORKS

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Introduction

The point of departure for this paper is expressed frustration with continuing inability to improve America's schools, despite massive Federal expenditures, and the question of whether, in a decentralized educational system, the Federal Government should seek to strengthen and extend the informal social networks through which experiences, insights, and innovations frequently flow.[1]

Frustration with progress in education is not new. One recalls Harold A. Innis' remarks at the end of a long and distinguished career in education:

> "A major problem of society emerges in the development of institutions which enlarge the capacities of individuals and enable them to use such enlarged capacities to the greatest advantage of the individual and the institutions. In this the state occupies a crucial position. Education has been largely concerned with conservation of knowledge, and in turn becomes extremely conservative... Educative discipline tends to preserve what has been acquired and presents very real obstacles to further advance.[2]

In the search for alternatives, a bold new orientation has been suggested by Ernest House, who used as a point of departure the work of a distinguished Swedish geographer, Torsten Hägerstrand:

> "To control the flow of personal contact is to control innovation. As the flow of blood is essential to human life, so direct personal contact is essential to the propagation of innovation, and, by tracing the flow of personal contact and personal influence, one can chart the likely course of innovation. Who knows whom and who talks to whom are powerful indications of where and when an innovation is accepted, or if it is accepted at all.[3]

Hägerstrand was slightly more circumspect:

> "Dissemination through private or group conversation easily outbalances other means of communication. Even today we are very neolithic in that respect, I am sure.[4]

Because the work of a geographer has attracted so much attention in the educational development community, it is wise that geographic concepts of innovation diffusion and educational development be evaluated with care. Such is the purpose of this paper, which seeks to clarify geographers' contributions to understanding the role of informal networks in the process of educational change, including methodologies developed for the study of informal and deliberately contrived networks, and for the identification of factors that stimulate or retard change and improvement. A second thread is intertwined, too: The transformation of geography itself.

We thus begin with an excursus into the intellectual history of geography, to clarify how and why Hägerstrand's ideas have revolutionized geographic thinking, as one example of educational change and development. We then examine Hägerstrand's models in detail, to illustrate how he clarified the role of personal contact networks in innovation diffusion and provided methodologies for studying the accompanying change process.

Excursus: Geographic Theories of Social Change

Less than half a century ago geographical thinking was dominated by a particular paradigm, one so strong that Pitirim Sorokin termed it the geographical theory and devoted one-sixth of his masterful review and critique Contemporary Sociological Theories to it in 1928.[5] "Almost since the beginning of man's history" he wrote "it has been known that the characteristics, behavior, social organization, social processes and historical destiny of a society depend upon the geographical environment" (p.99). Yet after his review of the environmentalists' hypotheses, he reflected that "At a beginning of a study of these theories one is impressed by their brilliancy and originality; continuing the study one is perplexed and bewildered by their contradiction and vagueness; and finally he is lost in the sea of those theories not knowing what in them is valid, and what is wrong or doubtful. This explains why the primary need in this field at the moment consists not so much in a formulation of a new geographical theory or a new "correlation" between geographical factors and social phenomena as in a most rigorous analysis and shifting (sic) of what is valid and what is childish in these numerous hypotheses" (p.101). But this rigorous analysis never came. By the 1930s environmentalism had gone out of style and geography had moved on to new topics.

The basic environmentalist idea was expressed no more clearly than by the first President of the Association of American Geographers, William Morris Davis, in his 1906 presidential address:[6] "any statement is of geographic quality if it contains... some relation between an element of inorganic control and one of organic response" (p. 71). Human society, Davis argued, was an organism which survived by adjustment to the physical environment; the nature of its growth was thus environmentally prescribed. This form of Social Darwinism he derived from the writings of Herbert Spencer.

Davis was a tireless scholar who sought for many years to impose uniformity of environmentalist concept on American geographic education, receiving stimulus

from widespread acceptance of the Darwinian hypothesis and the increased codification of knowledge about the environmental, racial and cultural differences existing in the world. His followers were well disciplined and adamant, seeking to "explain" all regional differences in terms of direct causal links to environmental conditions. Among the examples of the variables they "explained," as listed by Sorokin, were: population numbers, distribution and density; housing types; road location; clothing; the amount of wealth produced and owned by a society[T.H. Buckle's theory that the history of wealth in its early stages will depend almost entirely on soil and climate] leading to the idea that all brilliant and wealthy civilizations of early times have occurred in "favorable" natural environments, whereas "unfavorable" climates, inaccessible and isolated areas, breed backwardness and savagery; the location and nature of industry; business cycles and the rhythms of economic life [Ellsworth Huntington's meteorological theory of business cycles, as elaborated by H.L. Moore]; race [Buckle's concept that differences among societies in bodies, minds, social organization and historical destiny are environmentally determined, extended by the work of Ratzel and Semple, and the geographer-turned-anthropologist Franz Boas] suicide; insanity, crime; birth, death and marriage rates; religion, art and literature; social and political organization of society [e.g. Ratzel's theories of the state, in which states with large territories possess a spirit of expansion and militarism, an optimism and youthfulness, and a psychology of growth, with less social and racial conflicts than in small territories which are characterized by pessimism, earlier nationalism, stagnation and an absence of virility].

The leading environmental theories of social change were those of "Equatorial Drift" and the "Northward Course of Civilization". The theory of the northward course of civilization, articulated most clearly by Gilfillan in 1920 was that "the leadership in world civilization is inseparably linked with climate and that with advance in culture it has been transferred to colder lands, and when extant culture has been declined leadership usually has retreated southward...that the part of a civilization's banner has led steadily northward while culture was advancing and vice-versa." Beginning with Montesquieu, and restated many times

thereafter, the theory of equatorial drift was that peoples living at ease in the warm lowlands have been overrun by hardier races bred in the more rigorous climates further north or at higher altitudes.

The strongest hypotheses about civilization and climate were those of Ellsworth Huntington. He argued that climate is a decisive factor in health; that it determines physical and mental efficiency; that climate continually changes in time. He therefore concluded that climate determines the growth and decay of civilizations, their distribution on earth, and the historical destinies of nations. Since a civilization is the result of the energy, efficiency, intelligence, and genius of the population, and since these are determined by climate, ergo: climate is the factor in the progress or regress of civilizations.

As the environmentalist paradigm came to dominate American geography, alternative ideas were advanced and caveats offered, and it was out of these that a new paradigm of social progress emerged. Even that most arden determinist Ellen Churchill Semple said in 1911 that communication was critical. "It does not suffice that a people, in order to progress, should extend and multiply only its local relations to the land. This would eventuate in arrested development... The ideal basis of progress is the expansion of the world relations of a people, the extension of its field of activity and sphere of influence far beyond the limits of its own territory, by which it exchanges commodities and ideas...that intellectual force which feeds upon the nutritious food of wide comparisons. Every wide movement which has widened the geographical outlook of a people...has applied an intellectual and economic stimulus.[7]

Franz Boas, too, had begun to articulate the concept of cultural diffusion as a reaction against the unilinear evolutionism of E.B. Taylor and Lewis Henry Morgan. Boas was a German geographer whose role in the early development of anthropology in America is well-known. He argued that "there is not a single people...that has developed its culture independently."[8] Similar ideas are found in the work of France's leading human geographer, Vidal de la Blache,

who distinguished between rudimentary cultures, the expression of local environments, and superior civilizations that communicate with each other and are therefore capable of expansion. He equated stagnation with isolation that has "dried up the sap of invention" and evolution with innovations brought by contacts from favored nodal points to indigenous modes of life with sufficient vitality to use them. It is in the nodal regions that progress, he argued, has seldom been interrupted.[9]

It remained for Carl O. Sauer to crystallize the essential ideas:[10]

> The focused curiosity that bears the name 'geography' is or should be aware not only of the dependence of life on the physical environment, but also on the interdependence of living things in a common habitat, or of total ecology (p. 1).
>
> There is no general law of progress that all mankind follows; there are no general successions of learning, no stages of culture, through which all people tend to pass. There have been progressive cultures and others that show almost no signs of change. The latter are found in areas of high isolation; the former have been favored by the nature and location of their homelands...in a few ... physically favored areas some...center has burst forth into a great period of significant invention, from which ideas spread, and in part changed as they spread afield.
>
> In the history of man...difussion of ideas from a few hearths has been the rule; independent, parallel invention the exception (p. 3).

Environmentalist concern for the relations of nature and culture had given American geography its first explicit rationale, its first paradigm. The influence of environmentalism lessened during the 1930s, however. Its principal failure had been that it tried to describe nature and culture as separate entities with direct lines of causation from the former to the latter.

At first as environmentalism waned signs emerged that the discipline might move on to genetic-morphological frameworks, in which analyses were undertaken of parallel "natural landscapes" and "cultural landscapes" developing from youth through maturity to old age and rejuvenation. But this framework also proved objectionable to geographers and instead, in the 1930s and 1940s, American geography moved most affirmatively along the highly descriptive path of studying "areal differentiation." In this retreat to descriptive regionalism, professional geographers rejected all theory. A period of intellectual sterility followed that was ended by geography's "quantitative revolution" in the late 1950s.

This revolution was sparked by a group of young geographers at the University of Washington who sought to base their research on theories of location and spatial organization. They rejected the strong ties between descriptive geography and history, and instead sought to make geography a modern social science. They soon became aware of the work of a Swedish geographer, Torsten Hägerstrand, who developed dramatic new theories about spatial diffusion processes. There was interchange between Seattle and Lund, and it was from these two centers that the quantitative revolution diffused, first through the network of graduate geography, and subsequently to lower echelons of the field. Much of the interchange among the young revolutionaries was informal, for there was great resistance to the change in the formal structures of geography dominated by adherents of the older persuasions. Only when an accelerating bandwagon threatened to become a rout was the older school willing to adjust and accommodate.

Location theory brought with it a systems view of spatial organization: that the human geography of a region is to be understood in terms of :

Points of focus - activity centers organized functionally into hierachies, and linked by lines and channels of communication and movement - networks over which activity centers interact with each other and with surrounding.

areas of organization - regions linked to nodes, with characteristics patterned by the distance-decay that attenuates linkages betwen center and periphery.

The significance of diffusion theory was that it supported this systems view, providing insights into the role of communications in social change that enabled thinking to move away from the place-bound frameworks of environmentalism and from the constraints of evolutionary thinking, each of which talked about relationships among things at particular places or within particular regions, thereby viewing change as endogenous. Instead, Hägerstrand looked at connections among areas, and exogenous sources of change. Thus, "growth does not appear universally at any one time but manifests itself at points or poles of growth... and diffuses through the economy in definite channels."[11] Growth produced by the diffusion of innovations is, in this view, a process involving the "acceptance over time of some specific idea or practice by individuals, groups or other adopting units linked to specific channels of communication, to a social structure, and to a given system of values or culture."[12] The effect of diffusion -more properly development if it involves a positively-valued change in structure -is to continuously transform man-land relationships, for "every time a new implement or machine is invented or a new technique is devised, a new appraisal must be made of every scrap of territory and the possibility of a new orientation of human activities be predicated. Areal distributions are essentially impermanent."[13]

Thus,"diffusion has always had a catalytic function in sociocultural development. The comparatively rapid growth of human culture as a whole has been due to the ability of all societies to borrow elements from other cultures and to incorporate them into their own ... the necessity of integrating newly acquired elements into one's cultural heritage creates new problems, which demand new solutions and thereby engender new ideas. It was the opportunity for relatively rapid interchange of inventions and ideas between a number of local cultures that made possible the birth of the oldest civilizations in the Near East.

It was stimuli emanating from these oldest civilizations which started the chain reaction that eventually resulted in the emergence of one civilization after the other through the whole of human history. Obviously, the cultures of marginal peoples least exposed to diffusion... have remained the most primitive known in modern times."[14]

As noted, it was Torsten Hägerstrand who developed the first formal geographic model of diffusion processes.[15] Hägerstrand looked at a society as an ordered system in which all individuals and all pieces of material equipment, including land, are component parts, linked together in a multitude of ways. Diffusion, for him, involved the introduction of some new element that could propagate itself until it had permeated the system, and to some degree, had transformed it. Certain macroconcepts, linked together, comprised his model. These macroconcepts summarize the recurring characteristics of diffusion processes:

1. The growth curve. Diffusion tends to be characterized by an S-shaped curve of cumulative growth, with slow take-off, rapid intermediate growth, and declining later stages asymptotically approaching a final ceiling. The absolute pace of diffusion varies widely (the "diffusion time"), but the curve is remarkably repetitive.

2. Spatial expression of growth. The three stages of the growth curve have recurring counterparts in the development of the spatial pattern -
    a) Initial stage. Adoption tends to be concentrated in a cluster or clusters of centers of innovation.
    b) Intermediate stage. Expansion takes place by means of a neighborhood effect in which spread is more likely closer to existing adoptions, because the informal personal contact networks through which people learn about innovations are biased by distance-decay. Occasionally new centers of dispersal may arise from jumps of unexpected length.

c. Saturation stage. The original areas of dispersal fill, while the frontier is still advancing, up to barriers and at a pace controlled by local receptivity to change.

Hägerstrand's most important contribution was to develop a model of the neighborhood effect, given initial centers of innovation, by translating the distance-decay pattern of personal contacts into a contact-probability grid (the "mean information field") that could be used to simulate spread, using Monte Carlo methods. Later versions of his model built in individual psychological resistances to innovation and physical barriers to contact. He also realized that long-distance "jumps" were to be expected, the closer the relationship of the innovation to the modern urban scene, and he realized that urban innovations, in particular, tend to move from large cities to small down the urban hierarchy.

After Hägerstrand's contribution, work multiplied and finally achieved the status of an alternative geographic paradigm of social and economic change. The central ideas in geographic diffusion theory today are in large measure macroscopic in scale, excepting those that follow directly in Hägerstrand's footsteps, relating to:

1. Centers of innovation and spread. Some centers, over long periods of time, emit wave after wave of innovations. Thus, Sauer tried to codify historical centers of agricultural innovation, and Perloff et. al.[16] have concluded that, in studying American regional development, the central driving force has been "a great heartland nucleation of industry and the national market, the focus of large-scale national-serving industry, the seedbed of new industry responding to the dynamic structure of national final demand, and the center of high levels of per capita income," and that standing in a dependent relationship to the heartland, "radiating out across the national landscape are... resource-dominant regional hinterlands specializing in the production of resource and intermediate outputs for which the heartland reaches out to satisfy the input requirements of its great manufacturing plants. Here in the

hinterlands, resource-endowment is a critical *determinant of the particular cumulative* advantage of the region and hence its growth potential."

In Perloff's view, the heartland experiences cumulative urban-industrial specialization, while each of the hinterlands finds its comparative advantage based on narrow and intensive specialization in a few resource subsectors, only diversifying when the extent of specialization enables the hinterland region to pass through that threshold scale of market necessary to support profitable local enterprise. Flows of raw materials inward and finished products outward articulate the whole.

This view focusses on the particular role of metropolitan centers. It is they that organize the space-economy. They are the centers of activity and of innovation, focal points of the transport and communications networks, locations of superior accessibility at which firms can most easily reap scale economies and at which industrial complexes can obtain the economies of localization and urbanization. It is they, therefore, that encourage labor specialization, areal specialization in productive activities, and efficiency in the provision of services. Metropolitan centers, standing at the top of the nation's urban hierarchy and at the center of each of its regions, are therfore the nodes whose connections integrate the national economy. Agricultural enterprise is more efficient inthe vicinity of cities. The more prosperous commercialized agricultures encircle the major cities, whereas the peripheries of the great urban regions are characterized by backward low-income economic systems.

The polarization of innovation in large metropolitan areas is a reflection of trends in the national space economy. Differential growth rates among cities are a function of competitive advantages, but as Thompson[17] points out, the long-run viability of a metropolitan area resides not so much in regional resources, traditionally viewed, but on its own capacity to invent and innovate, or otherwise acquire new resources and export bases. To follow his argument, he says that the economic base of the

larger metropolis is the creativity of its universities and research parks, the sophistication of its engineering firms and financial institutions, the persuasiveness of its public relations and advertising agencies, the flexibility of its transportation networks and utility systems, and all the dimensions of 'infrastructure' that facilitate the quick and orderly transfer from old dying bases to new growing ones. Larger urban areas, he argues, combine a favorable industry mix for growth with a steadily declining share of the various growth industries. High wage rates of the innovating area, quite consonant with the high skills needed at the beginning of the learning process, become excessive when skill requirements decline, and the industry (or parts of it) will then 'filter down' to smaller, less industrially sophisticated areas where the cheaper labor can meet the declining skills demands of the filtering industry, thus creating the phenomenon of small towns with low-wage, slow-growth filtered-down industry at the time when the metropolis has moved on to new bases. This capacity of the large metropolis to invent new economic bases means that large urban regions are free of narrow export dependency. At sufficient scale, infrastructure and residentiary development make the growth of the large metropolitan complex essentially self-generative, with a tendency to grow at or about the rate of the nation. Moreover, the "circular and cumulative causation" of innovation breeding further innovation continually reaffirms the growth of the metropolitan cores, and leads Friedmann and Miller[18] "to interpret the spatial structure of the United States in ways that will emphasize a pattern consisting of one, metropolitan areas and two, the inter-metropolitan periphery. Except for thinly populated parts of the American interior, the inter-metropolitan periphery includes all the areas that intervene among metropolitan regions and that are, as it were the reverse image of the trend towards large scale concentrated settlement that has persisted in this country for over half a century. Like a devil's mirror, much of the periphery has developed a socio-economic profile that perversely reflects the very opposite of metropolitan virility.[4]

2. Channels of spread. Hägerstrand emphasized that in general innovational movements urban centers

tend to function as nodes channelling spread, but that over a broader range of innovations it is important to understand the role of the regular paths by which information is exchanged, including the spatial range of contacts displaying, most frequently, the distance-decay pattern that leads to the neighborhood effect. Combining the two ideas, it has been argued elsewhere that there are two major elements in the city-centered organization of economic activites in space that are important in moulding the growth processes currently operating in the country:

(a) A system of cities, arranged in a hierarchy according to the functions performed by each.

(b) Corresponding areas of urban influence surrounding each of the cities in the system.

We know the following about this system of spatial organization:

(a) The size and functions of a central city, the size of its urban field, and the spatial extent of developmental "spread effects" radiating outwards from it are proportional.

(b) Impulses of economic change are transmitted in order from higher to lower centers in the urban hierarchy, in a 'size-ratchet' sequence, so that continued innovation in large cities remains critical for extension of growth over the complete economic system.

(c) The spatial incidence of economic growth is a function of distance from the central city. Troughs of economic backwardness lie in the most inaccessible areas along the peripheries between the least accessible lower-level centers in the hierarchy.

(d) The growth potential of an area situated along an axis between two cities is a function of the intensity of interaction between them.

To this we should, of course, add the influence of the networks of communication and transportation connecting the areas of influence to the cities and the cities to each other, determining by their layout

and efficiency the pattern and extent of spread effects, the depths of peripheral troughs, and the configuration of growth axes.

The recent diffusion of television illustrates these organizing themes.[19] Television stations were installed by cities in the familiar S-shaped logistic time sequence, although affected by two periods of war. The diffusion pattern of stations among cities was essentially hierarchical. Large cities installed stations before smaller cities and, holding size constant, heartland cities adopted earlier than hinterland cities. The proportion of households purchasing television sets depended upon the hierarchical diffusion of broadcasting stations, but the spatial incidence of purchases was also a function of distance from broadcasting cities. As diffusion proceeded apace, market penetration neared completion first along the nation's principal growth axes and extended wavelike into the periphery. Continuing, total geographic coverage was achieved by 1958; low degrees of market penetration remained thereafter only in the nation's troughs of economic backwardness.

Two contrasting views about growth processes that reappear in the literature intertwine here. One view is that if metropolitan development is sustained at high levels, differences betwen center and periphery should be eliminated and the space-economy should be integrated by outward flows of growth impulses through the urban hierarchy, and the inward migration of labor to cities. Troughs of economic backwardness at the intermetropolitan periphery should, thereby, be eroded, and each area should find itself within the influence fields of a variety of urban centers of a variety of sizes. Continued urban-industrial expansion in major central cities should lead to catalytic impacts on surrounding regions. Growth impulses and economic advancement should "trickle down" to smaller places and ultimately infuse dynamism into even the most tradition-bound peripheries.

This equilibrating" theme is contested by Mydral's notions of "unbalanced growth," that inequities tend to increase rather than decrease:[20] "In the centres of expansion increased demand will spur investment, which in turn will increase incomes and demand and cause a

second round of investment ... the banking system ... tends to become an instrument siphoning off savings from the poorer regions to the richer and more progressive ones where returns on capital are high and secure(p. 28) ... (and which) are on the whole firmly settled in a pattern of continuing economic development, while (in the poorer regions) average progress is slower ... in recent decades the economic inequalities between developed and underdeveloped ... have been increasing." (p.59). If a "first-most" effect characterizes the beneficiaries of innovations, then it certainly seems that Myrdal's hypothesis should hold, because in most diffusion processes, the couplet is completed by "troughs last- and least."

3. Boundary effects. If there are regular centers of innovation and channels of diffusion, a third element, boundaries - physical, political, cultural - affects the pattern of spread by inhibiting contacts across the boundary. Such boundaries may be completely impermeable, defining self-contained spatial systems, or they may be only partially "absorbing" in their effect, or even partially "reflecting" so that innovations which would otherwise diffuse outside the system "bounce back" to some point within it. Such is the intent, for example, of tariff restrictions on trade.

4. Receptivity factors. Finally, differing groups and cultures may have differing capacities and willingness to adopt particular innovations, and thus may accelerated or retard the diffusion process. Such receptivity factors have been examined more closely in the micro-studies discussed in the next section, however.

Contemporary geographic theories of social change thus tend to focus on diffusion processes as the growth mechanism and to explore the ways in which innovations induce growth within, or lead to the transformation of, spatial systems. There is, for example, concern about the changes that take place when spatially-distinct locally-segmented societies begin to interact and to create new interdependencies, growing differentiation, and increasing complementarity. To cite one example, a study of the geography of modernization in Kenya:[21] "geographical patterns

of modernization reflect the relative extent of social mobilization throughout the state-area and, by association, are closely linked to the development of a national network of social communications." "The modernizing society is ... an emerging spatial system, a geographical community functionally organized to promote the interrelated processes of social, economic and political change..." "Traditional society in Kenya, for example, was characterized by small units, ethnically circumscribed and inwardly focussed. Communications were almost entirely informal, personal and oral. Rarely did distinct circulatory organizations exist, for the flow of information was usually guided by social attributes, such as clan membership or position within a social hierarchy. The environment, especially the existence of physical barriers and the friction of distance, restircted both the extent and intensity of communications so that the effective "world view" of any particular group was relatively narrow and usually confined to the group itself and its immediate neighbors." "Colonialism had the effect of creating a new and stronger pattern of circulation within larger units of organization. With the drawing of boundaries and the spread of effective administration came the genesis of transition. Traditional society was virtually forced to change, and at a more rapid pace than ever before, through increasing contact with modern cultures."

An increasing ingredient of intentionality emerges from this view, for colonialism (itself an innovation) introduced revolutionary changes into the Kenyan spatial system, many by design. Most diffusion studies thus reemphasize the role of man as initiator, planner, executor, and achiever of goals.

For much of his history man and his geographers tended to see the content and ordering of his life as relatively fixed. Where change was or might be taking place, it was thought to be through the agencies of gods or fate, or the inexorable working of natural law or the forces of historical evolution. Man's role was limited to suffering the results, or cooperating with change to achieve latent, but strictly prescribed, potentialities.

Diffusion theory has played an important role in demythologizing nature and history, and revealing man's role in change; thus geography now increasingly views man as a potential initiator: "expansion and modernization of transport communications is a key stimulus to growth in areas of the developing world where market place trading is a relatively recent innovation;" and "colonial use of taxing powers and creation of market places, together with road improvement, was instrumental in changing the economic and social development of the area" are but two of the relevant quotations culled from one recent work.

The view of man as an initiator spills over into the notion of the geographer as planner. The realization of man's capacity to induce change in desired directions has thus led geographers most recently to new rounds of theorizing about the spatial structuring of growth to achieve stated ends. A new orientation has appeared in which goals are set, research carried on, decisions are made and implemented. To the extent that this process is successful, the accompanying change is intentional.

For example, from the understanding that the developmental role of urban centers in the United States involves the simultaneous filtering of the innovations that bring growth down the urban hierarchy and the spreading of the benefits accruing from the resulting growth both nationally from core to hinterland regions, and within these regions from their metropolitan centers outwards to the intermetropolitan periphery, geographers have been led to the formulation of growth center theory and strategies.

The distinction is already drawn, therefore, in the sense of Amitai Etzioni, between diffusion in an "ongoing" society, which in the absence of adequate collective social control, causes driftlike change of an incremental kind and occasional revolutionary transformations and a "self-transforming" society which can exercise control over the forces of change. The growth center strategy has all three features required by any self-transforming society:

1) It is cybernetic in that it involves the collection, precessing (coming to conclusions) and use (introduction into the decision-making and implementation process) of knowledge.

2) It has a power-mobilizing characteristic in that it implies social capacity to translate knowledge into policy and to redistribute the assets of society in the interest of collective action.

3) It attempts to build consensus by bringing growth and redistributing wealth to what would otherwise be an increasingly dependent and alienated periphery.

Much recent theorizing in geography tends to emphasize the basic building blocks required for effective structuring of spatial systems: efficient locations of nodes and centers and their arrangements in hierarchies; efficient development of transport and communication networks linking the hierarchies of nodes; efficient movements and interactions over the networks; and the resulting surfaces and regions that flesh out the spatial organization.[22] Network development is seen as playing three vital roles in spatial evolution, for example: generating node-connecting sequences, space-filling sequences, and space-patitioning sequences.[23] Regionalization is seen as a tool to achieve explicit ends. Theories of the urban hierarchy, of industrial location, of network structures and flows, of spatial interdependence, converge in the arena of planned change.

Hägerstrand's Models

Much of the foregoing work is macro-spatial, yet Hägerstrand's precipitating models focussed upon the individual, upon interpersonal communication, upon individual awareness, receptivity, acceptance and change--an outstanding example of the use of empirical microanalysis in the construction of theory.

Hägerstrand developed three models, each a successively better means of simulating an actual diffusion process.[24] He began by asking why population characteristics varied spatially-- why there were regularities in the spatial distributions -- and he observed that frequently, these characteristics were learned elsewhere before they were adopted locally. Innovation waves in time (the characteristic S-shaped logistic growth curve), he observed tended to be accompanied by waves of diffusion in space in which three stages tended to follow in sequence:

Stage 1. Local concentrations of initial acceptances.

Stage 2. Radial dissemination outward from the initial agglomerations is accompanied by the rise of secondary agglomerations, while those original centers simultaneously continue to condense.

Stage 3. The growth ceases (saturation stage).

What, he asked, are the "primary factors - the fewer the better - with whose help we can analyze the diffusion process itself, or the change from one point in time to another?" (p. 135).

Suppose, he said, we are dealing with an imaginary area with completely homogeneous qualities, with uniform population density, gridded into cells of equal size, and let us proceed with "the obviously basic idea that a cultural innovation can be accepted by a person only if he is aware of its existence. In other words, the behavior of a population toward a cultural innovation must be closely related to the distribution of information concerning the new phenomenon. This premise leads to the following simple observations: the distribution of information is synonymous with the distribution of informed persons; the cultural element in question cannot be found where information does not exist; and the existence of

information about an innovation does not in itself guarantee acceptance." (p.138)

Two kinds of information were distinguished: public information, defined as information widely broadast to many people without the intervention (and possible alteration) by some third party, and private information, requiring person-to-person contact.

His simplest case, Model I, generated a completely random spatial distribution under conditions of public information. The assumptions were these:

1) From the beginning the entire population was informed about the innovation.
2) Acceptances occur independently of one another in a random order of precedence.
3) The course of the growth curve is not considered.

The inhabitants of the model area were numbered from 1 to 2,430. Random numbers were selected between 1 and 2,430 and a list of the order of acceptances constructed. If a nunber came up a second time it was ignored. Successive maps were drawn with 25, 50, 100 and 200 acceptances to show the emergence of the simulated random spatial distribution.

Examining the results, Hägerstrand concluded "The assumptions made thus far are not realistic. In reality one or more factors cause an innovation to be accepted more rapidily in certain limited areas than in others. To obtain the same result in a model, we must abandom the assumptions of Model I and introduce new ones which bring into play certain spatial restrictions in the model population's freedom of action. The possible barriers to diffusion can be imagined to be divided as follows: (a) unevenly distributed willingness or opportunity to accept the innovation (uneven "receptiveness"), (b) an uneven distribution of information concerning the innovation, or (c) some combination of both factor groups." (p.148)

Looking back at his data, be observed a repeated neighborhood or proximity effect (i.e. innovations tended to occur near other innovations), and concluded that differential access to private information constituted the primary influence that in turn was modified in differential receptivity. He then turned

to the question of the private information field, that region of awareness within which an individual's informal social network is located.

Examination of data on migration and telephone communications led him to conclude that private information fields varied statistically around a normal or common distance-decay gradient from the individual or center. The density of contacts, communications, and information decrease with increasing distance within a single person's information field, but with a consistency and regularity within any given region that is possible to postulate the existence of a mean information field for the population within that region.

Measurement of the mean information field enabled him to construct Model II. Suppose, he said, we can construct such a field for a given area (the case chosen was migration, for Asby in Sweden). Then the mean information field (MIF), although in fact continuous in all directions from the center, can be summarized in the form of a 5x5 set of grid cells showing the probability that a contact will be made from an outlying cell to the center cell:

.0096	.0140	.0168	.0140	.0096
.0140	.0301	.0547	.0301	.0140
.0168	.0547	.4431	.0547	.0168
.0140	.01301	.0547	.0301	.0140
.0096	.0140	.0168	.0140	.0096

Random numbers can be assigned to facilitate use of the MIF in simulating spread of the innovation:

0000	0096	0236	0404	0544
0095	0235	0403	0543	0639
0640	0780	1081	1628	1929
0779	1080	1627	1928	2068
2069	2237	2784	7215	7762
2236	2783	7214	7761	7929
7930	8070	8371	8918	9219
8069	8370	8917	9218	9358
9359	9455	9595	9763	9903
9454	9495	9762	9902	9999

Then he proceeded to his simulations, assuming the following:

1) In the beginning, only one person in the population is informed about the innovation.
2) Acceptance occurs immediately following the receipt of information.
3) Knowledge regarding the innovation is forwarded only via private information.
4) Information is always forwarded at a constant time interval (generational interval) from one informed person, to other already informed persons, or to persons not previously not informed.

The simulation was again performed on his model plane. The new element was assumed to spread from a single individual living at the center of the plane. The MIF was centered on the cell in which this teller resided and a random number was drawn to designate the receiving cell. The first contact drawn in turn became a teller during the second step. At this step there were two tellers--first one and a new one. The MIF was then centered over each of the two tellers to determine the next round of receivers who in turn became tellers along with the previous tellers who continue to tell. The process was repeated over several steps until the number of potential contacts was exhausted. Thus, in contrast to Model I, adoptions are not independent events, but dependent on prior events via the expression of private communication networks in the MIF. As a result initial agglomerations of varying density and radial dissemination from these centers are much more characteristic of the simulated patterns.

But even then, the simulated patterns did not go far enough. In some of the phenomenon studied dense concentrations emerged, separated from relatively unaffected areas by sharp boundaries. The resistances producing these patterns were built into Model III. Psychological resistance to acceptance was scaled along a normal curve, according to the number of tellings required before adoption, viz:

Adopter category	A	B	C	D	E
Probability of resistance	.067	.233	.400	.233	.067
Require tellings	1	2	3	4	5

This scaling was used to assign a distribution of resistances to the population in each study area cell.

The assumptions of the model thus became:

1) Only one person in the population has accepted the fictional innovation from the beginning.
2) Acceptance does not occur until resistance (according to the given scale) has been overcome through repeated receipt of private information from persons who previously accepted the innovation.
3) Information is always forwarded after a constant time interval (the generational interval).

Simulating in this framework, Hagerstrand found that the spatial patterns that emerged showed even greater realism : central stability of a higher density zone of adoptions, but also the emergence of secondary centers from which the innovation also diffused, sharper boundaries between adopting and lagging areas, a longer time-period of incipient growth and convergence on saturation at a lower level of overall penetration by the innovation.

Finally, still further "realism" (i.e. closer matches between actual and simulated patterns) was achieved by simulating on a real population distribution rather than a homogeneous grid, and by interposing real barriers to communication such as unbridged rivers, seen as reducing the probability of contact.

Change-Agents in Other Spaces: Meyer on an American Montessori Education

Hagerstrand's formulations transformed geographical thinking, forcing geographers to focus on the processes producing spatial patterns in a behavioral framework, although, as noted earlier, the natural inclination of many geographers was to use his framework as a guideline for macro-scale inquiries. A plethora of studies has followed, the majority of which have been ably reviewed and summarized elsewhere.[25] One application is of particular interest in the present context, however, Judith Meyer's Diffusion of an American Montessori Education.[26]

Meyer began by observing the intriguing parallels between education and diffusion, learning and adoption, and formulated a study of the diffusion of an educational innovation in the Hagerstrand framework. Yet as she proceeded, she found that Hagerstrand's models were inappropriate in their strict geographical sense (but not, as we shall see, topologically). Three different groups were involved in the diffusion process: organizers of American Montessori classrooms, individuals who became teachers, and the American Montessori Society and its founder, Nancy Rambusch. Ultimately, her study became one of the diffusers' perceptions and decision making, especially that of Nancy Rambusch.

Ms. Mayer found that adopters were homophilous: primarly of middle to upper middle class, interested in private education, living in communities within major metropolitan areas characterized by high proportions of college-educated residents. Half the Montessori study groups were organized by parents, the balance by teachers and existing schools. Teacher training was a key element, and since this was the responsibility of the American Montessori Society, Nancy Rambusch's role became critical.

Rambusch's perception of the market determined the AMS network that emerged. An upper middle class Catholic mother herself, she focussed upon middle-class Catholic parents as she promoted Montessori education. The diffusion process was wrenched out of the geographic space that concerned Hagerstrand and

:ook place instead in a particular segment of social space: that perceived as relevant by the leading change agent, and penetrated by her missionary and organizational activities. AMS functioned as a clearinghouse for Montessori education in the United States, promoting, publishing, advertising, facilitating communications in annual national seminars, operating a "materials center" for teachers. Ultimately, too, successful schools began to stimulate further adoptions of Montessori education, and permitted experimentation with alternative approaches to that education.

Meyer concluded that much of the Hagerstrand-stimulated work in geography has focussed on the "effects" that "explain" a considerable proportion of the variance of adoptions of innovation in space and time. These effects, in particular, have been those of distance-decay, derived from the idea that interpersonal communication declines as distance increases, and of hierarchical diffusion, based upon notions of market size and propensities to interact in cities of different size. Yet she found that a more penetrating behavioral analysis of the diffusion process demands analysis of change agents and diffusers, their perceptions of their market surface, how they relate to this surface, and how they ultimately either reinforce it or change it.

For Meyer, then, the key questions in diffusion research are exactly those that motivate NIE's interest in networking: how such change-agent activity creates informal communities that enable educational problem-solving to be improved, and how innovations in educational problem-solving may be diffused by deliberate change-agent activity. Rambusch had an innovation, selected a market, and was quite successful. Her behavior was clearly consistent with an old social-psychological paradigm: structure influences behavior only when filtered through screens of cognition. The perceptions were those of Rambusch. She filtered out of the total market structure a particular segment, and directed her activities to that market segment. Thus, to complete the social-psychological paradigm, her behavior set in motion a change process that, in turn, circled back and changed the structure. American

Montessori education did diffuse, was adopted, did change educational practices. Yet the "space" in which that diffusion took place was not that of Hägerstrand's geographical neighborhood, described by a consensus mean information field. Rambusch's personal information field was to be found in social rather than geographic space, and it was in that space that AMS's activities had most acceptance and success.

Implications for Networking

Hagerstrand's models reveal several important things for those interested in networking as a deliberate activity:

- public information produces more widespread innovation than private information; strong neighborhood effects occur in the diffusion of innovations when private information fields are localized and distance-decay is steep.

- improvements in communications and transportation serve to widen mean information fields, improve access, lessen the restrictiveness of private information, and hasten diffusion.[27]

- intense social psychological resistance to adoption of innovations can retard diffusion.

- poorly-connected networks contain chasms and barriers that slow diffusion and channel its paths; well connected networks are not afflicted by such impediments.[28]

- given knowledge of the network within which the innovation is to diffuse, social-psychological resistances, and the shape of the mean information field, the diffusion process can be simulated using Monte Carlo methods.

To Hagerstrand's formulation, Meyer adds the following:

- in the diffusion of many innovations, particular change agents play a key role; the personal information field is theirs, as is the perception of the market segment to be reached, and the creation of the network through which the task is to be accomplished.[29]

These conclusions suggest that a variety of questions must be explored by those interested in educational networking. Among these questions are the following, suggesting in turn a strategy for systematic research on networking:

1. What are the items to be diffused via an informal interpersonal network?

2. Who are the change agents? Is their perception of the market segment to prevail?

3. In what space is that market segment located? Is it geographical, or is it defined with respect to one or more social dimensions?

4. Is information about the innovation to be public or private? If private, what information field will serve to produce neighborhood effects with their clusters of adopters?

5. Is it possible to change diffusion patterns by increasing the public content of communications, thereby diminishing the distance-decay component of personal information fields based upon face to face contacts?

The power of the Hagerstrand formulation was, of course, that it permitted assumptions to be changed and the consequences of the changes to be observed in studying spatial diffusion, because it led to the development of successively more satisfactory simulation models. The opportunity in educational networking is, albeit in social rather than geographical space, to produce experimental models of similar incisiveness by following Hägerstrand's logic-first by developing descriptive and inductive models of the stages of innovation diffusion out of a series of carefully designed comparative case studies, and second, by proceeding to the development of the simulation models. Hägerstrand's contributions became part of a geographical revolution; one might wish for nothing less in education.

FOOTNOTES

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